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International Journal of Current Research
Vol. 9, Issue, 07, pp.54578-54580, July, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

BATTERY ENERGY STORAGE DEVICE BASED RENEWABLE POWER GENERATION SYSTEMS – A SURVEY

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ARTICLE INFO

Article History:
Received 28th April, 2017
Received in revised form
11th May, 2017
Accepted 17th June, 2017
Published online 31st July, 2017

Key words:

Renewable energy System,
Battery, State of Charge,
Reliability, Optimization.

ABSTRACT

This is a review paper which focuses on the different energy storage devices based renewable power generation systems. The renewable energy systems are progressively being accepted because these are environmental friendly and freely available. These energy systems can play an important role in remote places where power is not viable to be transported from long distances. On the other hand, tapping the renewable energy from the natural sources such as sun and wind has its own demerits. Due to varying weather conditions, the renewable energy systems are not able to satisfy the load demand. To enhance the power accessibility and supply of the reliable power to the load, the battery energy storage devices are essential in off-grid applications. This paper is intended to review the types of energy storage devices with effective Maximum Power Point Tracking controller and control strategies for optimizing the performance of the system.

Citation: Vanajaa, V.R. and Dr. Kathirvel, C. 2017. "Battery energy storage device based renewable power generation systems - A survey", *International Journal of Current Research*, 9, (07), 54578-54580.

INTRODUCTION

Rapid depletion of non-renewable source of energy in addition to increase in the price of fossil fuels has forced people to look for alternative energy which is clean and environmental friendly. For minimizing the emissions from greenhouse gases and to meet the increasing power demand, the world now focuses on renewable energy sources like solar, wind, hydro, tidal and so on. From these solar and wind energy are prominent and more viable when compared to all other renewable energy sources. These renewable sources generate power depending on the atmospheric conditions. To satisfy the load demand, a combination of renewable energy sources with energy storage devices that are suitable for off-grid applications with better reliability is required. The advanced control strategy is implemented in a standalone PV, Diesel and Battery based micro grid for improving the robustness and accuracy of the system. The storage devices have been supplied uninterrupted power to the load with minimum cost (Julia Sachs and Oliver Sawodny, 2016). The standalone PV, Wind, Battery with Tidal hybrid system is introduced for improving the accuracy of the system.

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The size of the battery storage system can be optimized by crow search algorithm. The State of Charge such as charging mode and discharging mode is to be obtained by different methods. The hybrid system has to meet the load demand aided by the battery storage which reduces the cost and improves the reliability of the system (Alireza Askarzadeh, 2017). The hybrid PV, Battery with Hydro system proposes a hierarchical controller for parallel operation of PV with Battery and hydropower system. A small-signal state-space model is used for improving the stability of the system (Yajuan Guan *et al.,* 2015). The PV with battery system is introduced with three port converter with zero current switching to improve the efficiency of the system. The power supply from the battery to the load has been maintained by the FPGA based battery management algorithm (Hongyu Zhu *et al.,* 2015). During the absence of solar and wind power, the storage device supplies reliable power to the load. To improve the life of the battery with zero Loss of Power Supply Probability, a sizing procedure is recommended (Rajan Singaravel and Arul Daniel, 2013). Battery plays an important role in a standalone renewable energy system especially for rural applications. However reliability and efficiency are still challenging issues particularly for off-grid applications. This paper will focuses on reviewing the types of energy storage devices with different

algorithms and control strategies for stand-alone as well as grid connected systems.

Lead-acid energy storage system

A grid connected PV with Battery and Ultra Capacitor based hybrid system is introduced with the energy management strategy for stable output power. The state of charge of the lead acid battery storage unit is performed by control strategy. The buck-boost converter with PI controller is used to store the energy in the battery effectively which compensate the energy gap between the PV power generation and load demand. The DC–DC bidirectional converter is to guarantee the charge and discharge operation of the storage unit and the PI controller generates the duty cycle of the converter efficiently (Adel Choudar, 2015). Fig.1 illustrates the general block diagram of the hybrid system.

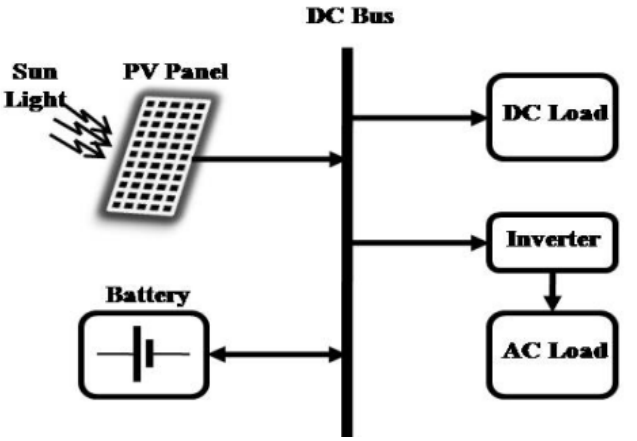

Fig. 1. Block diagram of a hybrid system

The performance of the two different lead acid batteries are analyzed with their parameters such as charge, discharge and over charge are calculated mathematically and the simulation results are compared with the real time data of two different PV panels and the better model have been chosen (Achaibou *et al.,* 2012).

2014). A standalone PV, wind with lead acid battery is proposed with a modified particle swarm optimization algorithm for reducing the size of the storage system with low cost, shorter computational time and faster convergence speed as compared with conventional method (Ahmed Hassan *et al.,* 2015). An autonomous PV with lead acid storage device is controlled based on sliding-mode control. It guarantees a reliable output voltage with low total harmonic distortion under nonlinear load conditions (Thang *et al.,* 2015). The different charging stages have been analyzed by safe battery charging algorithm for increasing the life of the lead acid battery. The Single ended primary inductor converter is used to match the impedance between PV panel and battery to deliver the highest power (Joseph Brian D'Souza and Bharathi A Rao, 2016). The Fig. 2 illustrates the typical value of voltage band of a 12V lead acid mono block from fully discharged to fully charged.

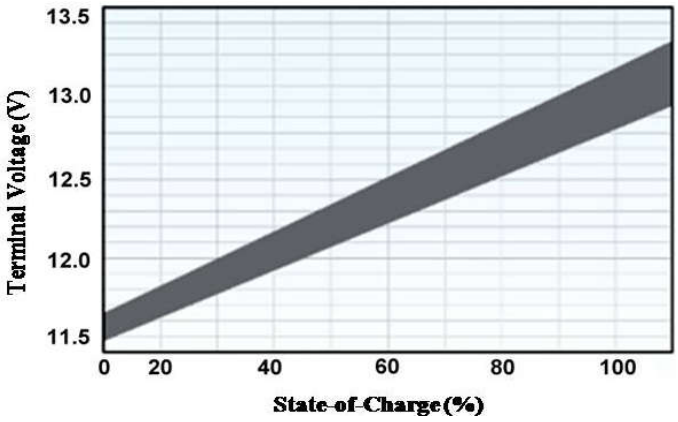

Fig. 2. Typical Voltage band of a 12V lead acid battery

Nickel based energy storage system

The PV with nickel-zinc battery system is introduced with fuzzy logic control algorithm to maximizing the charging efficiency of the storage device. Charge controller circuit is used to match the impedance between solar array and micro battery.

Table 1. Publications on recover highest possible charging capability through different MPPT algorithms and control strategies

Authors, Year	*PV	Wind	*UC	*LA	*LI	*Ni	*CS	*A
Joseph Brian D'Souza et al., 2016	●			●				●
Sherif A. Abdelrazek et al., 2016	●				●			●
Ahmed Hassan et al., 2015	●	●		●				●
T.V.Thang et al., 2015	●			●			●	
Adel Choudar et al., 2015	●		●	●			●	
Sonal Gaurav et al., 2015	●			●			●	
Hisham Mahmood et al., 2014	●			●			●	
Pritpal Singh et al., 2006	●					●		●
Thomas L. Gibson et al., 2009	●				●			●
Kazuya BKZYAMA et al., 2000	●					●	●	

*PV-Photovoltaic System *UC-Ultra Capacitor *LA-Lead Acid battery *LI-Lithium-Ion based battery
*Ni-Nickel based battery * CS-Control Strategy *A-Algorithm

This paper deals with the energy management of micro grid through different modes of PV and battery operations. The charging and discharging conditions of the battery are regulated by DC-DC bidirectional converter based on the load requirement (Sonal Gaurav *et al.,* 2015). An autonomous PV based energy storage system is used for uninterruptable power supplying to the load when sufficient power is not generated by the PV array. The hybrid system is controlled by an adaptive droop control strategy (Hisham Mahmood *et al.,* The duty cycle may be adjusted to estimate the state of charge based on the voltage of the battery system (Pritpal Singh *et al.,* 2006). The table.1 shows the publications on maximum possible power has been stored in energy storage devices through different algorithms based MPPT controllers and control methods. The cylindrical PV module with nickel metal hydride batteries reduces the area of the installation. To increase the charging current of the battery an electric double layer capacitor is used which also reduces the volume and weight of the energy storage system (Akiyama *et al.,* 2000).

The PV with Nickel-Hydrogen battery system describes the performance of the battery with minimum pressure differential by battery re-initialization procedure. To maintain the health of the battery, the temperature and voltage between two cells are evaluated (Hajela and Cohen, 2002).

Lithium based energy storage system

To analyze the best dynamic performance of the lithium ion battery, different types of tests are carried out in different models of the storage system. Based on the accuracy, the sensitivity of different initial State of Charge values has been examined through dual polarization model based Robust Extended Kalman Filter approach (Hongwen He *et al.,* 2011). The PV system with lithium polymer energy storage system is introduced for active power management. The state of charge of the battery is verified by the energy time shift algorithm which maintains discharge during peak load time period (Sherif *et al.,* 2016). The PV module is used to charge the Iron phosphate type lithium-ion cells for electric vehicles and commercial recharging is optimized by self regulating system. The state of charge is calculated during charging and discharging cycles of the battery (Thomas *et al.,* 2009). The performance of the lithium ion phosphate battery with PV system is analyzed for high reliability and stability. The voltage control algorithm based MPPT controller reduces the charging time of the storage device efficiently (Flavio Palmiro *et al.,* 2015).

Conclusion

This paper is an attempt to review the optimum management of the different types of energy storage devices with good accuracy. In order to achieve maximum utilization of the storage devices with diminutive State of Charging time and load power fluctuations under both dynamic and steady state working conditions, various optimization algorithms and control strategies have been employed.

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